We claim:

1   1.   A process for determining at least one candidate spectral endmember that

2   represents a group of N spectra comprising:

3   building an initial endmember set composed of at least a first and a second

4   spectrum representing at least a first and a second spectral characteristic expected to be in

5   the group of N spectra;

6   unmixing the N spectra within the group of N spectra to determine what portion,

7   if any, of each of the N spectra match at least one of the at least a first and second

8   spectrum;

9   calculating a first metric value for each of the N spectra, wherein the first metric

10 value accounts for a remaining portion of each of the N spectra not matching the at least a

11 first and second spectrum;

12   defining a metric value range, wherein the N spectra having first metric values

13 within the metric value range are defined as M spectra;

14   ordering the M spectra from highest first metric value to lowest first metric value;

15   comparing each of the M spectra, beginning with the M spectra having the highest

16 first metric value, to each of the N spectra, to determine the frequency with which each of

17 the M spectra occurs within the N spectra; and

18   calculating a second metric value for each of the M spectra, wherein the second

19 metric value combines the frequency of occurrence of each of the M spectra within the N

20 spectra with a first metric value for each of the M spectra, wherein the M spectra having

21 the largest second metric value is the at least one candidate endmember.

1   2.   The process according to claim 1, wherein the at least a first and a second spectra

2   are selected from the group consisting of vegetation, shade, soil, and nonphotosynthetic

3   vegetation.

1   3.   The process according to claim 1, wherein the step of calculating a first metric for

2   each of the N spectra includes defining an error value for each of the N spectra as the

3   component not matching a combination of the at least a first and second spectrum.

1   4.   A process for determining at least one candidate spectral endmember that

2   represents a group of N spectra comprising:

3   building an initial endmember set composed of at least a first and a second

4   spectrum representing at least a first and a second spectral characteristic expected to be in

5   the group of N spectra;

6   unmixing the N spectra within the group of spectra to determine what portion, if

7   any, of each of the N spectra match at least one of the at least a first and a second

8   spectrum;

9   defining an error value for each of the N spectra, wherein the error value is the

10   portion of each of the N spectra that does not match a combination of the at least a first

11   and a second spectrum;

12   comparing the error value for each of the N spectra to a predetermined error value

13   range, wherein spectra having error values within the predetermined error value range are

14   defined as M spectra;

15   ordering the M spectra from highest error value to lowest error value;

16   comparing each of the M spectra, beginning with the M spectra having the highest

17   error value, to each of the N spectra, to determine the frequency with which each of the

18   M spectra occurs within the N spectra; and

19   calculating a metric for each of the M spectra, wherein the metric combines the

20   frequency of occurrence of each of the M spectra within the N spectra with an error value

21   for each of the M spectra, wherein the M spectra having the largest metric is the at least

22   one candidate endmember.

1   5.   The process according to claim 4, wherein the at least a first and a second

2   spectrum are selected from the group consisting of vegetation, shade, soil, and

3   nonphotosynthetic vegetation.

1   6.   The process according to claim 4, wherein each error value corresponds to a

2   residual spectra and the residual spectra in combination form a residual spectrum of the N

3   pixels.

1   7.   The process according to claim 6, further comprising calculating a root mean

2   square (RMS) error value for each of the N pixels by combining the error values for the

3   residual spectrum.

1   8.   The process according to claim 7, wherein the step of comparing the error value

2   for each of the N spectra to a predetermined error value range, wherein spectra having

3   error values within the predetermined error value range are defined as M spectra

4   includes:

5   determining an acceptable range of deviation from the mean RMS error;

6   comparing each of the RMS error values for each of the N pixels to the acceptable

7   range of deviation from the mean RMS error and keeping the M pixels that are within the

8   acceptable range.

1   9.   The process according to claim 8, wherein the step of calculating a metric for

2   each of the M spectra includes solving the following equations, wherein K_x represents

3   each of the M spectra, from x = 1 to x = an upper limit, RMSval(K_x) is the RMS error

4   value for the corresponding M pixel, RMSval(min) is the minimum RMS error value for

5   the M spectra, RMSval(max) is the maximum RMS error value for the M spectra,

6   RMSfreq(K_x) is the value corresponding to the number of N pixels that match the

7   residual spectrum for the corresponding RMS error value for the M pixel, RMSfreq(min)

8   is the number of occurrences of the least frequently occurring residual spectrum from the

9   M pixel residual spectra, and RMSfreq(max) is the number of occurrences of the most

10 frequently occurring residual spectrum from the M pixel residual spectra,

11
12 $$\text{Normval}(K_x) = \frac{\text{RMSval}(K_x) - \text{RMSval(min)}}{\text{RMSval(max)} - \text{RMSval(min)}}$$
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14
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17 $$\text{Normfreq}(K_x) = \frac{\text{RMSfreq}(K_x) - \text{RMSfreq(min)}}{\text{RMSfreq(max)} - \text{RMSfreq(min)}}$$
18
19
20 $$\text{wgtfactor}(K_x) = \text{sqrt}(\text{Normval}(K_x) * \text{Normfreq}(K_x)).$$
21

1   10.   A process for determining at least one candidate spectral endmember within a

2   scene having N pixels using scene spectral data comprising:

3   building a first endmember, wherein the first endmember represents a first

4   spectral characteristic expected to be in the scene;

5   building a second endmember for the scene, wherein the second endmember

6 represents a second spectral characteristic expected to be in the scene;

7   unmixing the N pixels in the scene to determine what portions of each of the N

8 pixels match at least one of the first and second endmembers;

9   defining a remaining portion for each of the N pixels not matching a combination

10 of the first and second endmembers as an error value, wherein each error value

11 corresponds to a residual spectra and the residual spectra in combination form a residual

12 spectrum of the N pixels;

13   calculating a root mean square (RMS) error for the N pixels by combining the

14 error values for the residual spectra;

15   determining an acceptable range of deviation from the mean RMS error;

16   comparing each of the RMS error values for each of the N pixels to the acceptable

17 range of deviation from the mean RMS error and keeping the M pixels that are within the

18 acceptable range of deviation;

19   ordering the M pixels from highest RMS error value to lowest RMS error value;

20   comparing the corresponding residual spectra of the M pixels, beginning with the

21 M pixel having the highest RMS error value, to the residual spectrum comprising the

22 residual spectrum for the N pixels, to determine the frequency with which each of the

23 corresponding residual spectra of the M pixels occurs within the residual spectra for the

24 N pixels; and

25   calculating a weighting factor for each of the M pixels, wherein the M pixel

26 having the largest weighting factor is the at least one candidate endmember.

1   11.   The process according to claim 10, wherein the first endmember is a shade

2   endmember and further wherein the shade endmember is determined by a pre-selected

3   baseline percentage of reflectance.

1   12.   The process according to claim 11, wherein the second endmember is a vegetation

2   endmember and further wherein the vegetation endmember is determined by comparing

3   scene spectral data for the N pixels to a known set of vegetation spectra.

1   13.   The process according to claim 11, wherein the second endmember is a soil

2   endmember and further wherein the soil endmember is determined by comparing scene

3   spectral data for the N pixels to a known set of soil spectra.

1   14.   The process according to claim 11, wherein the second endmember is a

2   nonphotosynthetic vegetation endmember and further wherein the nonphotosynthetic

3   vegetation endmember set is determined by comparing scene spectral data for the N

4   pixels to a known set of nonphotosynthetic vegetation spectra.

1   15.   The process according to claim 12, wherein the step of comparing the scene

2   spectral data for the N pixels to a known spectral data utilizes at least one spectral

3   mapping algorithm.

1   16.   The process according to claim 10, wherein the predetermined number of Z pixels

2   is at most 500.

1   17.   The process according to claim 10, wherein the step of calculating a weighting

2   factor for each of the predetermined number of M pixels includes solving the following

3   equations, wherein K_x represents each of the predetermined number of M pixels, from x =

4   1 to x = an upper limit, RMSval(K_x) is the RMS error value for the corresponding M

5   pixel, RMSval(min) is the minimum RMS error value for the M spectra, RMSval(max) is

24

6   the maximum RMS error value for the M spectra, $RMSfreq(K_x)$ is the value

7   corresponding to the number of N pixels that match the residual spectrum for the

8   corresponding RMS error value for the M pixel, RMSfreq(min) is the number of

9   occurrences of the least frequently occurring residual spectrum from the N pixel residual

10   spectra, and RMSfreq(max) is the number of occurrences of the most frequently

11   occurring residual spectrum from the N pixel residual spectra,

12
13   $$Normval(K_x) = \frac{RMSval(K_x) - RMSval(min)}{RMSval(max) - RMSval(min)}$$
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17   $$Normfreq(K_x) = \frac{RMSfreq(K_x) - RMSfreq(min)}{RMSfreq(max) - RMSfreq(min)}$$
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21   $$wgtfactor(K_x) = sqrt(Normval(K_x) * Normfreq(K_x)).$$
22

1   18.   The process according to claim 10, wherein the step of comparing the

2   corresponding residual spectrum of the M pixels, beginning with the M pixel having the

3   highest RMS error value, to the residual spectra for the N pixels, to determine the

4   frequency with which each of the corresponding residual spectra of the M pixels occurs

5   within the residual spectrum for the N pixels utilizes at least one spectral matching

6   algorithm.

1   19.   The process according to claim 10, further comprising applying a shade mask to

2   the unmixed pixels, such that only those of the N pixels not masked out are subject to the

3   calculation of a root mean square error step.

1   20.   The process according to claim 19, wherein the shade mask masks out the

2   unmixed pixels comprised of greater than 80 percent shade.

1   21.   The process according to claim 10, wherein the pre-selected baseline percentage

2   of reflectance is at most 1 percent.

1   22.   The process according to claim 10, wherein the scene spectral data is

2   hyperspectral data.

1   23.   The process according to claim 10, wherein the scene spectral data is

2   multispectral data.

1   24.   The process according to claim 10, wherein the scene spectral data is ultraspectral

2   data.

1   25.   The process according to claim 10, wherein the unmixing is linear.

1   26.   The process according to claim 10, wherein the unmixing is non-linear.